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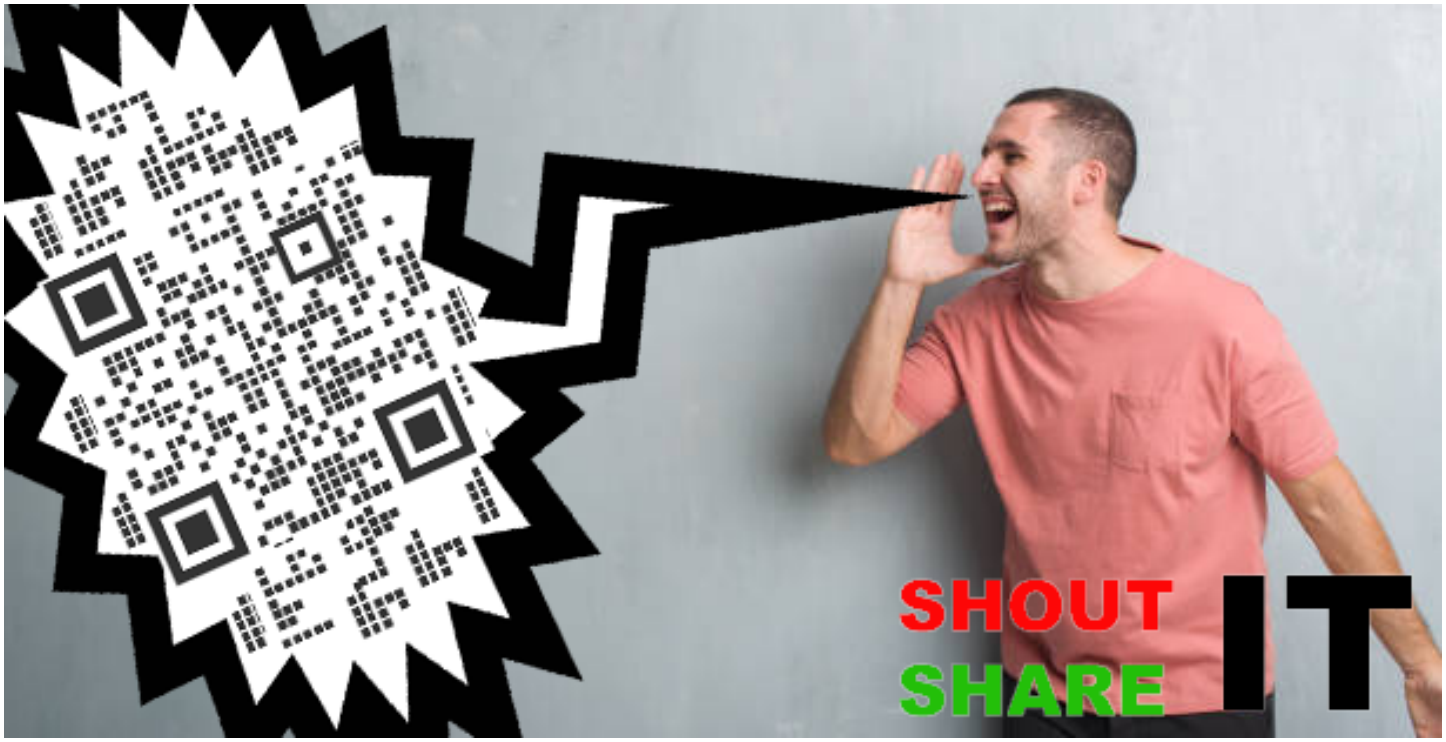
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Bulletin 81

PALEONTOLOGY 11

GEOLOGY

OF THE

WATKINS AND ELMIRA QUADRANGLES

ACCOMPANIED BY A GEOLOGIC MAP

BY
JOHN M. CLARKE *State Geologist and Paleontologist*
AND
D. DANA LUTHER *Field Assistant*

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PALEONTOLOGY 11

GEOLOGY

OF THE

WATKINS AND ELMIRA QUADRANGLES

ACCOMPANIED BY A GEOLOGIC MAP

BY JOHN M. CLARKE AND D. DANA LUTHER

The detailed mapping of this area has been carried out as a continuation of the work beginning farther to the west and will be found to be a pictorial representation of the upper series of the formations likewise shown in detail on the Canandaigua-Naples sheet which has but recently been issued. The field traverses for this map have been made by D. Dana Luther, in which he has had the help, as field assistant, of H. S. Mattimore. An interval remains between the area here presented and that covered by the Canandaigua-Naples sheet and this is now in process of survey and will be ready for publication in the near future. The large scale of these maps has permitted the delineation of the variations in the formations with very great exactitude and the basis of discrimination for these refined subdivisions has been both a lithologic and a paleontologic one.

Experience has taught us that, in this work, which now requires patient effort and precise methods, a reliable basis of classification can be found in neither of these elements alone and in this entire series of maps we have employed the two standards referred to. In the determination of the stratigraphic distinctions here represented pertaining to the late Devonic, obscurities and perplexities increase from Canandaigua lake eastward and they have therefore, on the map now presented, been treated with the utmost caution.

SUCCESSION OF STRATA

The following formations are represented on the map:

- Neodevonic
  - Chautauquan
    - Chemung sandstone and shale
    - Prattsburg shale
  - Senecan
    - High Point sandstone
    - West Hill flags and shale
    - Grimes sandstone
    - Hatch shale and flags
    - Rhinestreet black shale
    - Parrish limestone, in the
    - Cashaqua shale
    - West River shale
    - Genundewa limestone
    - Genesee shale

Genesee shale

The lowest formation exposed within the limits of the northern or Watkins quadrangle is the Genesee black slate which outcrops slightly at the water's edge 443 feet A. T., in a low arch on the west side of Seneca lake south of Fir Tree point and 6 miles from the head of the lake. Here are about 6 feet of black slaty shale above the water level but this is partially covered by the cliff talus. Toward the west this formation increases in thickness and is well exposed in the ravines along Seneca lake at the north and also along the shores of Canandaigua lake. In the Genesee valley it is 90 feet thick but from there westward it decreases rapidly and on the shore of Lake Erie at the mouth of Pike creek it is but 12 inches in thickness. Eastward from this meridian it decreases in thickness and the formation of which it is a member is not recognized beyond Smyrna, Chenango co. The rock is nearly all densely black bituminous shale, some layers of which are slightly argillaceous or calcareous and lighter colored. Calcareous concretions occur at intervals, usually in the lighter beds.

Fossils are very rare and none were observed in these outcrops. Elsewhere the following species are found to be highly characteristic: Liorhynchus quadricostatus, Orbiculoidea lodensis, O. minuta, Lingula spatulata.

Genundewa limestone

This characteristic layer taking its name from exposures on Canandaigua lake is here one foot thick and divided in three uneven layers separated by thin shaly seams. It is hard, compact or concretionary and unevenly impure. The layers are usually separated by thin shales, are light bluish gray, sometimes mottled or clouded and weather to a brownish gray. At some exposures the limestone is principally composed of the minute pteropod Styliola fissurella, and for this reason has been commonly designated as the Styliola limestone.

This stratum emerges from the water of Seneca lake 443 feet A. T., 1 mile south of Fir Tree point, rises slightly toward the point for one half mile to about 6 feet above the lake level and then as slightly descends, disappearing under the water on the north side of Fir Tree point. On account of the eastward dip of the strata the limestone is covered by water on the east side of the lake. The formation is better developed and exposed farther to the west specially at Genundewa point and other places on Canandaigua lake; also at Bristol Center and near the foot of Honeoye lake in Ontario county; at Mt Morris below the Western New York and Pennsylvania Railroad bridge and at the high cascade in Little Beards creek at Moscow and other places in Livingston county. It may be traced still farther westward becoming thinner and more compact but retaining its peculiar features to the mouth of Pike creek in the town of Evans on the shore of Lake Erie. It is not known east of Seneca lake.

No fossils except Styliola fissurella have been found in this rock in this quadrangle but in Ontario and Livingston counties it contains a very considerable fauna, which is cited in full in Museum bulletin 63 and memoir 6.

West River shale

We have elsewhere made note of the fact that in the necessity of subdivision for the purpose of more exact correlation of the original Genesee slate of Professor Hall it has seemed best to retain that name in application to the lower part of the series as exhibited on

the Genesee river, for the lower beds are highly bituminous and regularly slaty and it was to indicate this bituminous character that the rock series was specially and separately designated. Regarding the Genundewa limestone as the boundary between the lower and upper divisions we have heretofore introduced as the designation for the latter the term West River shale. Here these shales are dark blue gray, medium hard, slightly calcareous with frequent thin layers of black shale. In weathered cliffs the mass has a dull black appearance. In the exposures on this quadrangle the formation attains a thickness of 35 feet. In it, 15 feet above the Genundewa limestone, is a concretionary calcareous layer 10 to 12 inches thick, sufficiently compact to appear as a layer of soft gray impure limestone; symmetrical concretions usually small are common in the upper beds. This upper calcareous layer was noted by D. F. Lincoln in his survey of Seneca county as occurring in Lodi glen.

Exposures of this West River shale are found only in the cliffs along the lake shore on the west side from Rock Stream point southward for about 3 miles when it dips under the lake. It comes up again at the head of the lake and the top is slightly exposed at a small culvert on the Northern Central Railroad ⅛ mile north of the Watkins railroad station and 6 feet above the lake. Except for a few insignificant outcrops it is mantled with drift and talus on the east side of the lake within this quadrangle but farther north the series is shown in the glen at Lodi and at Highland landing. On Canandaigua lake it is seen at Woodville and in the ravines at the north; also in the bluff at the mouth of the Genesee gorge at Mt Morris and at many places westward to Lake Erie. This division, like those previously mentioned, is thicker and its characteristic structure more highly developed in Ontario and Livingston counties; thence westward it grows thinner but without appreciable change in the character of the sediment.

Fossils are rare in the shales; Liorhynchus multicosta, Chonetes lepidus, Ambocoelia umbonata; Pterochaenia fragilis and Buchiola speciosa occasionally appearing. The concretionary limestone at the top carries other fossils: Nuculites oblongatus,

Loxonema noe, Bactrites aciculum, Manticoceras pattersoni, Gomphoceras cf. manes, Palaeotrochus praecursor, Pleurotomaria itylus, Palaeoneilo muta, Atrypa reticularis, Chonetes scitulus, Lingula spatulata.

Cashaqua shale

In the Naples valley at the base of these very characteristic beds there are 45 feet of shales, the larger part of which is black and bituminous. They constitute a distinct element in the succession there and have been designated as the Middlesex shale. Westward from Naples the formation becomes more bituminous and thinner and the lighter shales disappear. On the shore of Lake Erie, as exposed at the mouth of Pike creek, it is a band of black slaty shale 6 feet thick. Eastward from the Naples valley in Italy Hollow and on the shores of Keuka lake this division becomes less bituminous and more argillaceous and on this quadrangle its position is occupied by shales having the character of the typical Cashaqua shale at Naples and in the Genesee valley. The beds also contain, though in very small numbers, the fossils of those shales. The Middlesex shales therefore do not appear on this map.

The Cashaqua shale here attains a total thickness of 207 feet. At its base there are about 30 feet of soft argillaceous shale, dark bluish gray or olive in color, in which there are a few thin seams of black shale and an abundance of small calcareous concretions. Toward the top are 2 or 3 layers of evenly bedded bluish gray sandstone 4 to 10 inches thick. This lower horizon is finely exposed along the lake shore and in the rock cut of the Northern Central Railroad, 443 to 475 feet A. T. between Watkins and Salt Point, where the following fossils have been found: Manticoceras sp., Bactrites aciculum, Orthoceras sp., Styliolina fissurella, Palaeoneilo filosa, Pterochaenia fragilis, Paracardium doris, Buchiola cf. scabrosa. All these fossils are rare. These lower shales are overlain by an arenaceous band which, at the lowest rock exposure at the mouth of Watkins Glen, is composed of a 5 inch sandstone overlain by 5 inches of dark

shale followed by a sandstone 1 foot, 4 inches thick which is separated by a shaly parting from a compact gray sandstone 2 feet, 10 inches thick. The composition of this sandy band as a whole is somewhat variable but the heavy layer can be traced, gradually becoming thinner, from a mile north of Montour Falls on the west side of the valley for 10 miles, to the north line of the quadrangle, and for 2 miles on the east side near the head of the lake. It is quarried on both sides and supplies the building stone for Watkins and Montour Falls. A layer of rather soft sandstone next below the heaviest stratum in the quarry along the Watkins-Montour Falls road on the west side of the valley, ¼ mile south of the fair-grounds, 456 feet A. T. contained: Palaeoneilo constricta, Actinopteria cf. eta, Spirifer mesacostalis, Productella speciosa, Camarotoechia eximia, Liorhynchus mesacostalis, Orbiculoidea magnifica, Agelacrinites sp. nov., Plumalina densa.

This is the lowest brachiopod fauna found on this quadrangle and it was not observed at this horizon elsewhere. Bands of sandstone very similar to this occur at two horizons in the Cashaqua shale at Naples but they are not known farther west. Above these sandstones are soft bluish gray, olive and dark shales in thick or thin beds with thin sandstones usually blocky, slightly calcareous and weathering brown, but with some hard even layers from 3 to 10 inches thick succeeding each other for about 75 feet to a 2 foot sandstone containing large concretions exposed at the top of the cascade, ½ mile north of Montour Falls. Above this layer changes in sedimentation are somewhat less frequent, the layers of sandstone or shales being thicker, but the general character of the beds remains the same. The shales and sandstones immediately overlying the heavy sandstones below are almost barren, only a few obscure fossils occurring in the clay shales. A layer of dark soft shale exposed at the mouth of Havana glen 500 feet A. T. and about 50 feet above the sandstone contains: Nucula sp.?, Buchiola speciosa, Camarotoechia eximia. At 565 feet A. T. Plumalina plumularia is common in the thin sandstone; at 625 feet A. T., in compact soft shales Ambocoelia um-

bonata, Cyrtina hamiltonensis, Atrypa reticularis, Leptostrophia mucronata, Palaeoneilo constricta, P. cf. lamellata, Loxonema noe, Cladochonus sp., Manticoceras pattersoni and a small undescribed Diaphorostoma occur.

In an old quarry at 610 to 648 feet A. T., ¼ mile northwest of Montour Falls and in the same horizon at the top of Montour Falls and also by the roadside 10 rods farther north, the following species occur: Manticoceras pattersoni, Orthoceras cf. pacator, Styliolina fissurella, Palaeotrochus praecursor, Buchiola retrostriata, Lunulicardium hemicardioides, L. sp.?, Schizophoria impressa, Spirifer mucronatus posterus, Leptostrophia mucronata, Productella speciosa, P. lachrymosa, Ambocoelia umbonata, Chonetes lepidus.

The thin seam in shaly sandstone at 590 feet A. T. exposed on the road from Watkins to Burdett, ¼ mile north of Excelsior glen contains: Leptostrophia mucronata, Ambocoelia umbonata, Spirifer mesacostalis, Atrypa reticularis, Productella sp., Orthis tioga? and a mass of crinoid stems, and a similar layer at 580 feet A. T., ¼ mile northwest from Glenora contains Orthis impressa?, Chonetes lepidus, Ambocoelia umbonata, Productella cf. speciosa, and fragments of other brachiopods and small lamellibranchs. It will be noted that these faunules are essentially unlike, the lower beds containing species which typify the western normal Portage or Naples fauna while the upper beds contain an intermingling with some of these species of the brachiopods and lamellibranchs of the more eastern or normal Ithaca fauna.

Distinction between these two faunas will be less clearly marked in this region which marks the boundary line of the geographic provinces of the two. In regions farther west the brachiopod fauna is virtually and almost wholly excluded from these rocks. In the valley of Keuka lake the Ithaca fauna makes its appearance in the upper part of the Cashaqua beds, and emphasizes the interlocking

or dovetailing of the east and west faunas as has been brought out in previous discussions of these faunal relations.

Exposures. The Cashaqua shales are exposed in the Havana glen from the lowest outcrop upward for about 150 feet to near the base of the Bridal Veil falls. In Montour Falls ravine to the level of the first highway ridge; along the road from Montour Falls to Odessa up to 650 feet A. T.; in the ravine and quarries 1 mile east of Montour Falls; in Watkins Glen for 175 feet from the lowest rock exposure; in Excelsior glen 1 mile east of Watkins and along the road to Burdett to the first forks; the lower beds are shown along the Northern Central Railroad from Watkins to Salt point and the upper part in Rock Stream and Big Stream gorges to 40 feet below the level of the railroad tracks; also at Hector falls and Glen Eldredge, from the lake to the highway bridges. The Cashaqua shale is conveniently exposed at the following localities west of the Seneca lake valley: in ravines and low cliffs along the east and west shores of Keuka lake south of Bluff point; in the Belknap gully, ½ mile north of Branchport; in Parrish gully and many other ravines in the Naples valley; in Stony Brook glen at Dansville; along Cashaqua creek and the Western New York and Pennsylvania Railroad from Sonyea to Tuscarora; in the Genesee river gorge for 2½ miles south of Mt Morris; in the ravine west of Wyoming; in the ravine at Griswold, 6 miles west of Attica; in the bottom and sides of the Eighteen Mile creek gorge at North Evans and on Pike creek, ½ mile from Lake Erie.

Parrish limestone

We have already applied this name to an impure concretionary limestone, which in this region, occurs in nodular layers from 2 to 6 inches thick, separated by soft blue olive shales. This formation can be recognized in but few outcrops on this quadrangle and is not yet known east of the Seneca lake valley. It is continuous from here westward as far as the Naples valley where it consists of a single layer 4 inches in thickness, 50 feet, 8 inches below the top of the Cashaqua shale. In Italy hollow the next valley east of Naples it is a compact layer 8 inches thick. In the Belknap gully near Branchport it is 10 inches thick and 25 feet below the top of the

Cashaqua shale. In the Waggoner gully near the village of Poultney it is 1 foot, 6 inches thick in two or three layers and 15 feet below the top of the Cashaqua shale. In a small ravine west of Gibson's landing on Keuka lake it is 2 feet, 6 inches thick in four uneven nodular layers, separated by shale. The subdivision of the limestone into layers and the thinning out of that part of the Cashaqua shale above it continues to the Big Stream gorge near the north line of this quadrangle, where it is exposed west of and about 50 feet below the Northern Central Railroad. Here it consists of seven thin layers of concretionary limestone, separated by shale, the entire band having a thickness of 5 feet and it is overlain by the black Rhinestreet shale, the intervening light shales having thinned entirely out. The horizon is exposed in the Rock Stream gorge, ½ mile farther south but here the layers are less distinct and some of them have disappeared. In Glen Eldredge on the east side of the lake 3 miles north of Watkins but one layer of limestone appears, though the adjoining shales are quite calcareous. In its western outcrops, specially in the Naples valley this rock is singularly profuse in goniatites and other cephalopods. It is there more conspicuously than here tinted with shades of red and green. The only species observed in it on this quadrangle are Buchiola speciosa, Phragmostoma natator, Manticoceras pattersoni, Chonetes lepidus, Lingula sp. The horizon is shown not only at the points mentioned but also in the Big Stream gorge at 620 feet A. T.; in Watkins, Montour Falls, Havana, Eldredge and Excelsior glens at 630 feet A. T.

Rhinestreet shale

This is a mass of black compact shale which attains a thickness of but 10 to 12 inches. Like the Parrish limestone the formation is not known east of the Seneca lake valley. It increases in thickness toward the west at the average rate of nearly 2 feet a mile and on the shore of Lake Erie it is 185 feet thick. In the Genesee river gorge and westward it carries thin beds of lighter colored shale and rows of large septaria. It is exposed at the same points as stated for the previous formation. On this quadrangle the Rhinestreet

shale is quite barren of fossils, but in the Naples valley it carries masses of terrestrial plant remains, annelid teeth and rarely Lingula ligea; fish remains have been found in it in some abundance at Sparta, Livingston co. and near Mt Morris. The lighter colored layers in Erie county contain a few of the more common species of the Naples fauna.

Hatch shale and flags

Of this formation, which attains a thickness of 440 feet, the lower part is very much like the Cashaqua beds in the character of the sedimentation, consisting principally of soft blue or olive argillaceous shale and thin sandstones that are frequently laminated or schistose. There are occasionally thin seams of dark or black shale and some layers of sandstone are calcareous and concretionary, while most are silicious, light blue gray and hard. These flags are usually smooth on the lower surface while the upper is shaly or with wavy laminations, a condition characteristic of nearly all the thin sandstones in the Hatch division farther west. The changes from light to dark and from hard to soft are generally more pronounced in the upper part and in many natural outcrops. The frequent flags projecting beyond the soft shales produce a coarsely straticulate appearance. In the Naples valley the Hatch shales are 312 feet thick. The lower part contains a few fossils common in the Naples fauna but the upper part is almost barren except for obscure plant remains. No brachiopods have been found in them, in that vicinity or farther west.

The lower beds of this formation are exposed in Havana glen from the Curtain cascade upward; in the Montour Falls ravine above the bridge; in Watkins glen above 650 feet A. T.; in the Big Stream and Rock Stream ravines west of the Northern Central Railroad; in Glen Eldredge and the Hector falls ravine above the lowest highway bridge. The upper portion of the rocks is seen at Odessa and along the Lehigh Valley Railroad to the north.

West of this quadrangle the formation is exposed in the Glen brook at Hammondsport and along the dugway road on the east side of the head of Keuka lake; at Naples at the foot of Hatch hill and in the lower part of the Grimes and Tannery gullies; in the cliffs

along the Genesee river between Smoky Hollow and St Helena and along the shore of Lake Erie in the vicinity of Silver Creek.

Fossils are nowhere abundant but they are fairly common in a few horizons in the lower part. At 648 feet A. T. on the road from Montour Falls to Odessa, Spirifer laevis occurs in a 3 inch calcareous sandstone near the bottom of the formation. At about the same horizon in Havana glen are Productella speciosa, Schizophoria impressa, Atrypa reticularis and Centronella julia?; at 730 feet A. T. in soft shales, Manticoceras pattersoni, Loxonema noe, Honeoyea erinacea; at 772 feet A. T. Manticoceras pattersoni, Orthoceras, Atrypa reticularis, Cyrtina hamiltonensis, Cladochonus; at 782 feet A. T. Manticoceras pattersoni, Chonetes scitulus, C. lepidus, Productella spinulicosta, Strophalosia truncata, Leptostrophia mucronata, Spirifer subumbona, Cladochonus; at 803 feet A. T. Leptostrophia mucronata, Chonetes lepidus, Schizophoria impressa, Buchiola speciosa, Honeoyea erinacea and Lunulicardium ornatum; at 849 feet A. T. Manticoceras pattersoni; at about 868 feet A. T., in the Rock Stream ravine, occur Manticoceras pattersoni, Probeloceras lutheri, Tornoceras uniangulare, Bactrites, Buchiola speciosa, Paracardium doris, Pterochaenia fragilis, Styliolina fissurella, Bellerophon koeneni, Chonetes scitulus, Lingula cf. spatulata. In the quarry at Odessa, 1020 feet A. T., Buchiola speciosa, Paracardium doris, Pterochaenia fragilis and Palaeoneilo sp. occur.

It will be observed from this series of faunas that there are distinct oscillations between the western or true Naples fauna and the eastern or brachiopod fauna with some slight degree of intermingling of the two. For the most part however, here as elsewhere in this section, these two faunal elements are clearly distinct.

Grimes sandstone

This formation, which attains a thickness of 75 feet, is an arenaceous band in which the sandstones are from an inch to more than a foot in thickness and are separated by thin layers of dark bluish gray shales, the greater frequency of the sandstones constituting the principal difference so far as structure is concerned between it and the Hatch shales below, as well as from the overlying beds. In this quadrangle the formation is nowhere very well defined and is much more obscure than farther to the west; consequently the thickness here ascribed to it and the limits of the area over which it is the surface rock are partly based on data derived from the examination of the formation farther west and by tracing it to this vicinity. The rocks are exposed in the bed and sides of the Johnson Hollow brook 1 mile west of Lower Pine valley, 920 to 960 feet A. T.; at the cascade in the upper part of Watkins Glen, 4 miles west of Watkins below the second highway bridge west of the New York Central Railroad; the lower part at the top of the bank in the Lehigh Valley Railroad cut, 1 mile west of Odessa. At Hammondsport the formation is well shown along the highway on the east side at the head of Keuka lake near the top of the hill and in a ravine near the corner of the road. In Grimes gully at Naples the sandstones are at the crest of the Third falls, and a 4 inch blocky sandstone which is one of the lower layers, contains several species of Ithaca brachiopods. This is their first appearance in that section above the Genesee shale and the highest species of the Naples fauna occur a few feet lower. In the Genesee river gorge the sandstones are in the cliffs on the west side of St Helena and come down to the river level at the mouth of Wolf creek but no representatives of the Ithaca fauna occur in them in that section. Still farther west the sandstones thin out and are not easily recognized except at the most favorable exposures. They are shown in Walnut creek ravine 1 mile south of Silver Creek and in the cliff on the Lake Erie shore between Silver Creek and Dunkirk. On the Watkins quadrangle in some small old quarries in the bed and sides of the Johnson Hollow brook, 1 mile west of Lower Pine valley, at 920 feet A. T., the following species

occur in the shales and on the lower surface of one of the sandstones: Manticoceras pattersoni, Orthoceras sp., Phragmostoma natator, P. incisum, Palaeoneilo filosa, Nuculites oblongatus, N. cf. cuneiformis, Grammysia sp.?, Buchiola speciosa, Schizophoria impressa, Orthis tioga, Chonetes scitulus, Productella spinulicosta. They are not abundant here and were not found at other exposures of this horizon.

West Hill flags and shale

This division here attains a thickness of 315 feet. Its rocks consist of numerous thin, uneven flags 2 to 4 inches thick and occasionally compact even blue sandstones 6 inches to 1 foot, 6 inches thick, separated by dark soft bluish gray or olive sandy shales. Toward the west as far as the Naples valley brachiopods are common in these West Hill flags, specially at an horizon lying 100 to 150 feet above the Grimes sandstone.

In a small ravine 1 mile east of Hammondsport a calcareous lens in this formation, 1 foot, 6 inches thick and several rods long, is composed almost entirely of brachiopods, amongst which are Orthis tioga, Atrypa reticularis, Strophеodonta cayuta, Spirifer mesacostalis, Cyrtina hamiltonensis and Ambocoelia umbonata. It also contains a few goniatites and orthoceratites. Brachiopods are common at this horizon in the ravine south of the village. At Naples where the formation is typically exposed on West Hill, from which the name is derived, this fauna with several additional species appears at various places but the specimens are very much less than toward the east. Goniatites, which also occur in the Cashaqua shale below, are occasionally seen but the characteristic lamellibranchs and gastropods of the Naples fauna have not been found in this section at so high a horizon. In the Genesee river section and farther west the fossils of this horizon are exclusively of the Naples fauna, no brachiopods being known therefrom. In the Watkins and Elmira quadrangles both shales and sandstones are usually barren

but at some exposures they contain brachiopods in large numbers and occasionally species of the western Naples fauna. Concretions in sandy shale and thin sandstones exposed at 1060 to 1100 feet A. T. by the side of the road leading north from Johnson's hollow, 1 mile west of Millport, contain Liorhynchus mesacostalis, Atrypa reticularis, Chonetes deflectus, Productella lachrymosa, P. speciosa, Orthis carinata, Ambocoelia umbonata and Taxocrinus ithacensis. In the bed of the stream, 1 mile west of Pine Valley at 1045 feet A. T., are Orthis tioga, O. impressa, Atrypa reticularis, Spirifer mesacostalis. At 1030 feet A. T., in the small ravine at the north end of the quarry on the east side of Beers hill, 1 mile southwest of Pine Valley, a soft layer in the upper part of this formation contains: Phragmostoma natator, P. incisum, Buchiola speciosa, Pleurotomaria itylus. The same light soft shales at 1080 feet A. T., near the floor of the quarry contain Manticoceras sp. Phragmostoma natator, Buchiola speciosa, Palaeoneilo plana, Pleurotomaria itylus, Schizophoria impressa, Productella spinulicosta. In the upper part of the formation in the Pratt quarry at Elmira fossils are exceedingly rare, but imperfect specimens of Manticoceras pattersoni occur in a stratum of clayey shale at about 1050 feet A. T. Small fragments are found in small layers throughout the formation.

High Point sandstone

This formation, which attains a thickness of 85 feet, has somewhat the character of a very broad lentil with its greatest thickness in the meridian of the Genesee river, where it is a homogeneous mass of light bluish gray sandstone in layers 3 to 8 feet thick and aggregating 185 feet. It thins out rapidly and becomes softer toward the west and is hardly to be recognized on the shores of Lake Erie. It contains no brachiopods in or west of the Genesee river section. Its thickness also diminishes toward the east and gradually parts of the beds become shaly. It may be traced easily for 30 miles from the

Genesee river to the west side of the Naples valley where the harder layers project at the top of the cliffs at the south end of High Point. While the original description of the Portage sandstones on the Genesee river by James Hall, in his report on the geology of the fourth district, would apply except as to thickness, to most of the layers of the sandstone here represented, there are essential differences. Not only are the individual layers and the whole formation thinner and softer but an extensive calcareous lens in the middle of the section at Naples contains 23 species of brachiopods and 9 other organisms, none of which belong to the normal Naples fauna but are of distinctively later date. These lists have been given in various publications more specially in United States Geological Survey bulletin 16 and State Museum bulletin 63. Toward the east the formation becomes still softer and more unlike the typical section, but as the same changes take place in the adjacent beds above and below, it still appears as an arenaceous band composed of thin layers of sandstone separated by hard blue shale. On these quadrangles some of the sandstones are from 1 to 2 feet thick, compact and durable, with the characteristic light bluish gray color of the Portage sandstones and are quarried extensively in the vicinity of Elmira. At the bottom the change from the thin flags and soft shales of the West Hill beds is quite well defined but it is more gradual at the top. The formation, as here limited, includes the strata up to a horizon where soft blocky shales containing many brachiopods appear.

The rock is exposed on the hill east of Elmira at 1150 to 1200 feet A. T. and in the cliffs and quarries on the south side of the Chemung river west of Elmira at 1150 to 1200 feet A. T.; in the quarries at the mouth of the Latta brook ravine 920 to 950 feet A. T. and the Voight quarry ½ mile farther south at 940 feet A. T.; in the old quarry southwest of the station at North Elmira, 930 feet A. T.; in the Doane quarry 1 mile east of Horseheads and another ¼ mile north at 950 feet A. T.; in the quarry near the highway 2 miles north of Horseheads, 950 feet A. T. and two hillside quarries 1¼ miles south of Pine Valley, 1080 to 1160 feet A. T. and in a small ravine 1 mile west of Sullivanville, 1120 to 1200 feet A. T. Calcareous lenses are exposed in the East hill quarries at Elmira at 1060 feet

A. T.; the Doane quarry at 940 feet A. T. and near Sullivanville at 1150 feet A. T.

In respect to fossils the calcareous lenses which are composed wholly of brachiopods are found at several exposures of this formation and at different horizons. The shales also contain a few brachiopods and rarely a species which is elsewhere represented in the Naples fauna but very few of those which give the High Point fauna in the Naples region its distinctive character. The more common species are the following:

Spirifer mesastrialis *Hall*
Atrypa reticularis *Linné*
Productella lachrymosa *Hall*
P. speciosa *Hall*
P. onusta *Hall*
P. boydi *Hall*
Schizophoria impressa *Hall*
Orthis tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
Leptostrophia perplana *var.* nervosa *Hall*
Orthothetes chemungensis *Conrad*
Tropidoleptus carinatus *Conrad*
Liorhynchus mesacostalis *Vanuxem*
Chonetes scitulus *Hall*
Lingula *cf.* melie *Hall*
Lyriopecten tricostatus *Conrad*
Grammysia *sp.*
Manticoceras pattersoni *Hall*
Orthoceras *cf.* bebryx *Hall*

Prattsburg shale

These are soft olive or bluish shales with thin blocky sandstones and occasional layers of compact blue sandstone. Together they attain a thickness of 250 feet.

In the Genesee river section above the typical Portage sandstones are strata to which the above description applies, exposed in the ravine at Wiscoy and in ravines on the east side of the river to Long Beards riffs, 1 mile south of Fillmore where, in a heavy calcareous sandstone the first brachiopods above the Genesee shales are found. That is to say, the Long Beards riffs sandstone indicates the earliest appearance of the Chemung fauna with Spirifer disjunctus, no evidence of the Ithaca fauna being present in that section. This Wiscoy shale in the typical locality contains a few species of lamellibranchs and goniatites which are common to the Naples fauna below the Portage sandstones. The Wiscoy shale may be traced westward to Lake Erie showing but little change in lithologic character and fauna, but eastward the fauna is more arenaceous and south of Dansville, a distance of 25 miles east from Wiscoy, the

formation is mainly a laminated sandstone and is here crowded with brachiopods. So conspicuous is the development of this formation in the region from Dansville eastward, and so profuse and striking its development of the Chemung brachiopod fauna that on the map of the Naples quadrangle [N. Y. State Mus. Bul. 63] it was deemed advisable to apply to it the term Prattsburg sandstone and shale in preference to employing here the name Wiscoy, inasmuch as there has been this fundamental change in the nature of the fauna. In the Cohocton valley near Atlanta, the sandstones are still harder and are quarried for flagging and building stone. About Corning it has become softer and on the area of this map there is a return to conditions very similar to those at Wiscoy, so far as lithologic character is concerned.

This rock is exposed in the quarry near Pine City, 1120 feet A. T. and in that 1 mile west of the village of Southport, 1080 feet A. T.; along Hendy creek, from 1 to 3 miles west of the Chemung river, 920 to 1180 feet A. T.; in a ravine on the south side of Hawley hill, 960 feet A. T. and another 1½ miles farther west, 1050 to 1200 feet A. T.; at the south end of the bridge over the Chemung river, 1½ miles southwest from Big Flats at 920 feet A. T. The lower beds are shown in a small ravine at 1160 feet A. T. along the first road leading north in the Latta brook depression and the upper part a mile to the southwest by the side of the road leading from Maby hill; also in an old quarry 2 miles east of Horseheads at 1015 feet A. T. and in a ravine on the east side of Carr hill at 1150 feet A. T. There are field outcrops on the south side of Johnsons Hollow and the rocks are also seen in many small ravines on the northern part of the Elmira quadrangle.

Among the fossils occurring in the shales and sandstones of this division are the following:

Plumalina plumaria *Hall*
Chonetes scitulus *Hall*
Spirifer mucronatus posterus *Hall & Clarke*
Sp. mesastrialis *Hall*
Sp. mesacostalis *Hall*
Productella lachrymosa *Hall*
P. speciosa *Hall*
P. hirsuta *Hall*
Tropidoleptus carinatus *Conrad*
Liorhynchus mesacostalis *Vanuxem*
L. multicosta *Hall*
Atrypa reticularis *Linné*
A. hystrix *Hall*

Orthis impressa *Hall*
O. tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
S. inequistriata *Hall*
S. demissa *Conrad*
S. perplana *var.* nervosa *Hall*
Athyris polita *Hall*
Orthothetes chemungensis *Conrad*
Camarotoechia eximia *Hall*
C. *cf.* tethys *Hall*
Orbiculoidea *sp.*
Ambocoelia umbonata gregaria *Hall*
Lingula punctata *Hall*
L. spatulata *Hall*
L. *cf.* nuda *Hall*
Leptodesma potens *Hall*
L. maclurii *Hall*
L. billingsi *Hall*
L. robustum *Hall*
L. lichas *Hall*
L. spinigerum *Hall*
L. disparile *Hall*
L. matheri *Hall*
Leptodomus interplicatus *Clarke*
Paleoneilo filosa *Hall*
P. constricta *Conrad*
P. bisulcata *Hall*
P. *cf.* maxima *Hall*
Lyriopecten tricostatus *Vanuxem*
Pterinopecten imbecilis *Hall*
P. strictus *Hall*
Macrodon chemungensis *Hall*
Aviculopecten cancellatus *Hall*
Avicula *sp.?*
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Mytilarca carinata *Hall*
M. umbonata *Hall*
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Sphenotus clavulus *Hall*
Conocardium *sp.?*
Schizodus chemungensis *Hall*
Spathella *sp.?*
Cypricardella bellistriatus *Conrad*
Glossites *cf.* subtenuis *Hall*
Manticoceras pattersoni *Hall*
Orthoceras bebryx *var.* cayuga *Hall*
Phacops rana *Green*

Chemung sandstones

The term *Chemung* has been applied with such a breadth of meaning in New York stratigraphy that faunally and stratigraphically it no longer meets the requirements of precise expression. The formation has been, in a general and vague way, regarded as that mass of arenaceous deposits lying above the Portage of western New York and the Ithaca of central New York, from which there is, as is now known, a transition lithologically so gradual as to make a separation a pure convention. In respect to fauna the "Chemung group" has been commonly regarded as well defined by the presence of a notable series of species specially brachiopods, lamellibranchs and dictyosponges, all of which have been in a way regarded as centered about the species Spirifer disjunctus and the horizon, as a whole, including a thickness of from 1000 to 1500 feet of strata, regarded as the horizon of Spirifer disjunctus. This conception, as we have heretofore explained, is misleading, vague and inaccurate. The horizon of Spirifer disjunctus

follows close on the change from the Naples fauna in western New York at a high altitude above the base of the Portage formation. In central New York there is no such change but the gradation from the Ithaca fauna out of the Hamilton fauna upward into the association which carries species elsewhere concurrent with Sp. disjunctus is very easy and it is extremely difficult to draw a division plane anywhere except on the basis of refined distinctions into successive faunules. Spirifer disjunctus in this eastern region did not appear till this period of "Chemung" deposition was well nigh over. For a precise use of this term Chemung therefore we are thrown back on the original employment of the name and we here cite the explanation of the term as first used by Professor Hall, taken from the third report on the fourth geological district, 1839, pages 322-24.

Chemung group. The tops of the hills and high grounds in the towns of Erin, Veteran, and Catlin, display a group of rocks and fossils very distinct from those last described. The essential difference is the lithological characters of the sandstone of this group in the absence of argillaceous matter in most of the layers, these being nearly a pure silicious rock, harsh to the touch, and generally of a porous texture; while still a large proportion of the mass consists of compact shales and argillaceous sandstones of a softer texture than those below. The surface of the sandstone layers is rough, while those below are smooth and glossy, and being never rippled, prove that the rocks were deposited in a quiet sea.

A great variety of beautiful and characteristic fossils occur in the sandstone as well as the shale; many different from those of the group below, while several species exist in both. The principal ones are a species of Delthyris, the shell on each side extending into a wing, (D. alata ?) a Leptaena, Orthis, and a species of Avicula or Pterinea, ribbed like the common Pecten; besides several others of genera and species not before seen in the upper rocks.

The most northern extension of this group appears on the top of Buck mountain, near Millport, and on the high ground farther west; whence it is traced in the same direction to the valley of Port creek, on the western boundary of the county. The same rocks are found on the hills in Erin, and loose masses from above are scattered through all the low grounds hence to the Chemung river.

At about the latitude of Horseheads, in the northern part of the towns of Elmira, and Big Flats, this lower portion of the Chemung

group approaches nearly to the level of the valley. At Maybee's quarry, a mile and a half east of Horseheads, the rocks are quarried for the sandstone which is used for flagging, step stones, etc. These layers are highly silicious and compact; and sometimes contain a few fossils. They alternate with thick masses of shale; often several layers of the former separated by thin seams of the latter; and again, a thick mass of shale containing little silex and no sandstone. A similar quarry has been opened by Mr Tuilegar, 4 or 5 miles east of Elmira; and here the layers are very uniform, from ½ inch to 2 inches thick, and dividing by the vertical joints into slabs from 6 inches to 2 or 3 feet wide, and from 4 to 6 feet long. The sandstone contains a few species of Orthis, but the greater proportion of the fossils are found in the shale. Wisner's quarry is near the junction of this group, with the Ithaca group below, or rather in the upper part of the latter, which appears at this point, the rocks rising southward from Horseheads to the Chemung river.

The rocks of this group, containing an abundance of fossils, occur on a small creek coming into the Chemung valley from the northwest, and also on the Sing Sing creek, passing through the Big Flats. On the south side of the Chemung river, in Southport, the banks of the valley exhibit the rocks of this group with their peculiar fossils.

Between Elmira and Chemung they are seen at numerous points but nowhere in the county so well as at the Chemung upper narrows, about 11 miles below Elmira. Here the excavation for the road along the margin of the river has exposed more than 100 feet of rocks, containing abundance of the characteristic fossils, and in their greatest beauty and perfection. At a certain point in the mass exposed, we find a peculiar coralline fossil, confined to a thin stratum, and extending along the whole distance of the exposed rocks; it has also been found at other localities.

The mountain above the rocks exposed, at Chemung narrows, rises 400 to 500 feet, and is probably capped, as some of the hills in the neighborhood, by the conglomerate, which is the limit of the Chemung group upward. Farther south, near Tioga point, rocks of the same group occur in the bank from 100 to 200 feet above the river, and some of the sandstone layers are 3 to 4 feet thick, and highly silicious. I was informed that on the top of the hill the conglomerate is quarried for use on some of the public works below Tioga point.

At the Chemung upper narrows, and at several other localities there occurs in this group a stratum of concretionary sandstone of a peculiar character. In a few instances only are the concretions perfectly formed, but generally have one side imperfect, with a solid nucleus partially surrounded with concentric laminae, which easily

separate from each other; these are used for water vessels, &c., the concavity being often so great as to contain several gallons.

In the valley of Cayuta creek the group is exposed in a ravine 3 miles north of Factoryville, where fine flagstones could easily be obtained. In the north part of Barton are great numbers of loose masses containing the fossils of this group, probably washed down from the tops of the hills in the vicinity.

It will be seen that the definition of this formation is derived from the very region we have here under consideration and embraces those rocks to which we are now applying the term in the original and restricted meaning. On the Elmira quadrangle these rocks have a thickness of 800 feet. They are light and dark shales and light blue gray silicious sandstones in thin and thick beds. The sandstones are compact or schistose or may have thin wavy laminations. Large burls with the appearance of having been rolled while soft are common in the lower beds and the sandstones are frequently lentils that have but small extent. Some of the sandstones and shales in the upper part are ferruginous and when barren take on a brick red color. At 1720 feet A. T., on Ashland hill, is a thin layer of conglomerate and traces of it also appear in the vicinity of Seely creek. Calcareous lenses are very common and some of them in the middle part of the formation are composed principally of Leptostrophia perplana var. nervosa in very large individuals and these lenses may be from 1 to 2 feet thick and extend for many rods. The burls sometimes contain layers of fossils bent to conform to the shape of the concretion. At the base of this formation is a bed of black shale in a crumpled condition, as exposed 1 mile west of Pine City, overlain by uneven calcareous sandstones with calcareous lenses and 100 feet higher an old quarry shows a compact light gray sandstone with masses of fossils and 10 feet thick.

Exposures of this formation are seen in numerous roadside outcrops in the southern and western parts of the quadrangle and in a few quarries and ravines. Some of the more favorable exposures are in the higher quarries at Rosstown 1120 to 1300 feet A. T.; along a branch of Seely creek, 1½ miles northwest of Pine City at 1100 to 1200 feet A. T.; by the side of a road leading north

from Mudlick creek, 2 miles west of Seely creek at 1200 feet A. T.; in a quarry on Hawley hill, 3 miles west of Elmira, 1700 feet A. T. and a roadside outcrop 1 mile west, 1450 to 1700 feet A. T.; at 1100 to 1200 feet A. T., along the road leading from the flats 1 mile southwest of East Corning southward over the hill near the west line of the quadrangle.

The lower part of this zone is highly fossiliferous and both sandstones and shales in many places are crowded with large brachiopods and finely preserved lamellibranchs, for the most part of the same species as those in the division below.

Fossils are less abundant in the upper part above the horizon of the conglomerate but are still quite common and mostly of the same species as below. The following species have been observed:

Chonetes scitulus *Hall*
C. coronatus *Conrad*
Spirifer mesacostalis *Hall*
Sp. *cf.* ziczac *Hall*
Sp. marcyi *Hall* var.
Sp. mucronatus posterus *Hall & Clarke*
Sp. disjunctus *Sowerby*
Productella lachrymosa *Hall*
P. onusta *Hall*
P. hystricula *Hall*
Liorhynchus mesacostalis *Vanuxem*
L. globuliformis *Vanuxem*
Atrypa reticularis *Linné*
A. spinosa *Hall*
Orthis impressa *Hall*
O. tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
S. perplana *var.* nervosa *Hall*
S. mucronata *Conrad*
Athyris polita *Hall*
Orthothetes chemungensis *Conrad*
Camarotoechia eximia *Hall*
C. *cf.* tethys *Hall*
C. contracta *Hall*
Ambocoelia umbonata *Conrad*
Leptodesma longispinum *Hall*
L. sociale *Hall*
L. billingsi *Hall*
L. shumardi *Hall*
L. spinigerum *Hall*
L. agassizi *Hall*
L. disparile *Hall*
L. matheri *Hall*
Palaeoneilo filosa *Hall*
P. constricta *Conrad*
P. elongata *Hall*
P. emarginata *Hall*
Actinopteria *cf.* theta *Hall*
Lyriopecten tricostatus *Vanuxem*
P. priamus *Hall*
Microdon *sp.?*
M. *cf.* gregarius *Hall*
Liopteria chemungensis *Hall*
Modiomorpha subalata *Conrad*
Macrodon chemungensis *Hall*
Mytilarca simplex *Hall*
Grammysia *sp.?*
Sphenotus clavulus *Hall*
Pterinea chemungensis *Conrad*
P. *sp.?*
Schizodus oblatus *Hall*
S. chemungensis *Hall*
Spathella typica *Hall*
Cypricardinia indenta *Conrad*
Edmondia subovata *Hall*
Orthoceras *sp.?*
Pleurotomaria itys *Conrad* var.
Streptelasma *sp.*
Hydnoceras nodosum *Conrad*

UNDULATIONS

The aggregate thickness of geologic formations and parts of formations represented on the map of the Watkins and Elmira quadrangles is approximately 2244 feet, of which 1443 feet is by reason of the difference in elevation between the Genesee black shale exposed at the level of Seneca lake 443 feet A. T. on the south side of Fir Tree point, and the top of the hill near the south line of the Elmira quadrangle in the southeast corner of the town of Southport, and 801 feet is due to the southern dip of the strata between those points, an average of 24⅔ feet a mile.

From Fir Tree point the dip is toward the north and the average southern dip from the north line of the Watkins quadrangle to the south line of the Elmira quadrangle is 21 feet a mile.

This dip, however, is not constant. The heavy sandstones exposed in the quarries and ravines on the east side of the valley from Elmira to Horseheads and on the west side to Pine Valley, and the thick layer of similar character exposed on the west side almost continuously from a mile north of Montour Falls to the north line of the quadrangle, show the undulations to advantage.

From the southeast corner of the quadrangle the strata rise toward the north at an average rate of 60 feet a mile for about 6 miles to a point near the bend in the Chemung river east of Elmira.

At the south end of the Pratt shale quarry, Elmira, the dip is 26 feet a mile *north*. In the large quarries on the hill east of Elmira it varies from 150 to 200 feet a mile *north*.

In the Voight quarry 2 miles farther north it is 52 feet a mile north, and at the mouth of Latta brook, 43 feet a mile north.

The bottom of the synclinal is reached not far from the latitude of Horseheads, the quarry 1 mile north of the village, and the shale quarry ½ mile farther north showing no north or south dip while in the old quarry 2 miles north of Horseheads there is an elevation toward the north at the rate of about 150 feet a mile, and another quarry 2 miles farther north and other smaller outcrops show this southern dip is continued to the vicinity of Millport.

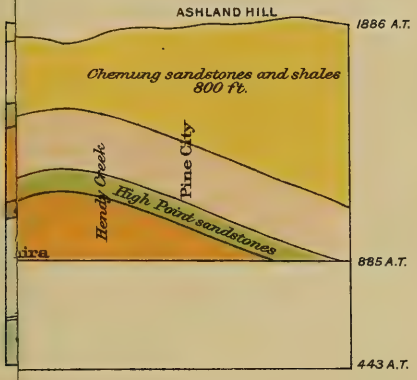
From Millport to a mile north of Montour Falls the dip seems to be 20 to 25 feet a mile south.

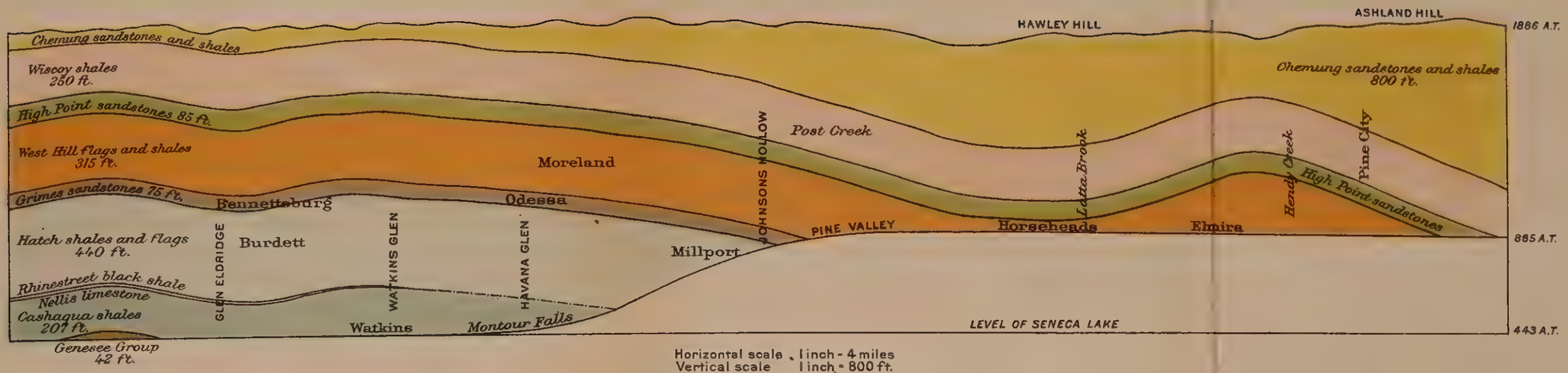
Along the road leading from Watkins to Montour Falls on the west side, there appears a mile north of the latter place, a compact sandstone 2 feet 4 inches thick, abundantly exposed toward the north, that is the most prominent feature in the stratigraphy of the lower rocks of this quadrangle.

At the south end of the exposure it is 450 feet A. T. and nearly level, but it soon rises toward the north and at the mouth of Watkins glen it is exposed at 480 feet A.T. The top of the anticline is reached about opposite the railroad station at Watkins at 490 feet A. T.

Thence northward it descends rapidly and disappears under the water of the lake ¼ mile north of Salt point; after sinking to about 25 feet below the lake level it rises again and emerges on the south side of Corbett point and continues to rise to Fir Tree point where it is 72 feet above the lake; thence it descends and reaches the lake level again near the north line of the quadrangle. There is an eastern dip of about 25 feet to the east side of the lake and the undulations are not so apparent except for 2 or 3 miles at the head, the strata farther north being covered to a large extent.

In the vicinity of Elmira there is a strong western dip. In the quarry at Pine City it is at the rate of 25 feet a mile, in the quarry 1¼ miles west of Southport, 130 feet a mile, and about the same at the south end of the bridge over the Chemung river 2 miles southwest of Big Flats. At the mouth of Latta brook ravine it is 22 feet a mile. In the shale quarry 1 mile northeast of Horseheads the strata descends toward the west at the rate of 75 feet a mile.


ASHLAND HILL
1886 A.T.
Chemung sandstones and shales
800 ft.
Pine City
Hendy Creek
High Point sandstones
885 A.T.
443 A.T.



Horizontal scale 1 inch = 4 miles
Vertical scale 1 inch = 800 ft.

Erratum. For Nellis limestone read *Parrish limestone*

uther, 1903

Field Work, by D. D. Luther, 1903

Contour Interval 20 feet

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New York State Museum

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Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
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Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. O. 1853.

Handbooks 1893-date. 7½x12½ cm.

In quantities, 1 cent for each 16 pages or less. Single copies postpaid as below.

B3 New York State Museum. 52p. il. *4c.*

Outlines history and work of the museum with list of staff 1902.

H13 Paleontology. 12p. *2c.*

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Maps. Merrill, F: J. H. Economic and Geologic Map of the State of New York; issued as part of Museum bulletin 15 and the 48th Museum Report, v. 1. 59x67 cm. 1894. Scale 14 miles to 1 inch. *15c.*

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form $3; mounted on rollers $5. Lower Hudson sheet 60c.*

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

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Geologic maps on the United States Geological Survey topographic base; scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.

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Area around Lake Placid. Mus. bul. 21. 1898.

Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. Mus. rep't 51, v. 1. 1899.

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Amsterdam quadrangle. Mus. bul. 34. 1900.

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Geologic map of the Watkins and Elmira quadrangles

with section

New York State Museum

The New York State Museum as at present organized is the outgrowth of the Natural History Survey of the State commenced in 1836. This was established at the expressed wish of the people to have some definite and positive knowledge of the mineral resources and of the vegetable and animal forms of the State. This wish was stated in memorials presented to the Legislature in 1834 by the Albany Institute and in 1835 by the American Institute of New York city and as a result of these and other influences the Legislature of 1835 passed a resolution requesting the secretary of state to report to that body a plan for "a complete geological survey of the State, which shall furnish a scientific and perfect account of its rocks, soils and materials and of their localities; a list of its mineralogical, botanical and zoological productions and provide for procuring and preserving specimens of the same; etc."

Pursuant to this request, Hon. John A. Dix, then secretary of state, presented to the Legislature of 1836 a report proposing a plan for a complete geologic, botanic and zoologic survey of the State. This report was adopted by the Legislature then in session and the governor was authorized to employ competent persons to carry out the plan which was at once put into effect.

The scientific staff of the Natural History Survey of 1836 consisted of John Torrey, botanist; James E. DeKay, zoologist; Lewis C. Beck, mineralogist; W. W. Mather, Ebenezer Emmons, Lardner Vanuxem and Timothy A. Conrad, geologists. In 1837 Professor Conrad was made paleontologist and James Hall, who had been an assistant to Professor Emmons, was appointed geologist to succeed Professor Vanuxem, who took Professor Conrad's place.

The heads of the several departments reported annually to the governor the results of their investigations, and these constituted the annual octavo reports which were published from 1837 to 1841. The final reports were published in quarto form, beginning at the close of the field work in 1841, and 3000 sets have been distributed, comprising four volumes of geology, one of mineralogy, two of botany, five of zoology, five of agriculture, and eight of paleontology.

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